

Factors Associated with Women's Adherence to Mammography Screening Guidelines

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Objective. To examine individual and environmental factors associated with adherence to mammography screening guidelines.

Data Sources. A unique data set that combines a national probability sample (1992 National Health Interview Survey); a national probability sample of mammography facility characteristics (1992 National Survey of Mammography Facilities); county-level data on 1990 HMO market share; and county-level data on the supply of primary care providers (1991 Area Resource File).

Study Design. The design was cross-sectional.

Data Extraction/Analysis. Data sets were linked to create an individual-level sample of women ages 50–74 (weighted $n = 2,026$). We used multipart, sequential logistic regression models to examine the predictors of having ever had mammography, having had recent mammography, and adherence to guidelines. We categorized women as adherent if they reported a lifetime number of exams appropriate for their age (based on screening every two years) and they reported having had an exam in the past two years.

Principal Findings. Only 27 percent of women had the age-appropriate number of screening exams (range 16 percent–37 percent), while 59 percent of women had been screened within two years. Women were significantly more likely to adhere to screening guidelines if they reported participating with their doctor in the decision to be screened; were younger; had smaller families, higher education and income, and a recent Pap smear; reported breast problems; and lived in an area with a higher percentage of mammography facilities with reminder systems, no shortage of primary care providers, higher HMO market share, and higher screening charges.

Conclusions. A small percentage of women adhere to screening guidelines, suggesting that adherence needs to become a focus of clinical, programmatic, and policy efforts.

Key Words. Mammography screening, healthcare utilization, environmental factors, patient/provider interactions, methods

Although numerous studies have examined factors associated with women having ever had mammography (Vernon 1990; Breen, Brown et al. 1996), little is known about the factors associated with women's adherence to screening guidelines. Understanding these factors is important, since only regular screening mammography has been shown to decrease breast cancer mortality (Fletcher, Black, Harris, et al. 1993; Nystrom, Rutqvist, Wall, et al. 1993; Kerlikowske, Grady, Rubin, et al. 1995). Although screening of women ages 40–49 continues to be controversial, there has been widespread consensus since guidelines were issued in 1977 that women ages 50–74 should be screened regularly (National Cancer Institute 1977). Yet, although a majority of women have had one mammography exam, women may not be screened regularly in accordance with the guidelines (Horton, Romans, and Cruess 1992).

The objective of this study was to examine factors associated with adherence to screening mammography guidelines and to compare these to factors associated with having ever had mammography or having had a recent mammography exam.

We address five gaps in the literature. First, most studies of regular screening have not used nationally representative samples, a problem that limits the generalizability of their results.

Second, most studies of regular screening (Fink, Shapiro, and Roester 1972; Lerman, Rimer, Trock, et al. 1990; Bastani, Marcus, and Hollatz-Brown 1991; Rimer, Trock, Engstrom, et al. 1991; Zapka and Stoddard 1991; Glanz,

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Resch, Blake. et al. 1992; Horton, Romans, and Cruess 1992; Smith and Haynes 1992; Zapka and Hosmer 1992; Love, Brown, Davis, et al. 1993; Miller and Champion 1993; Rakowski, Rimer, and Bryant 1993; Champion 1994; Bastani, Kaplan, Maxwell, et al. 1995; Burns, Freund, Ash, et al. 1995; Lee and Vogel 1995; Potvin, Camirand, and Beland 1995; Taylor, Taplin, Urban, et al. 1995) define adherence as having had more than one mammography exam or having had a recent exam, although a few studies have defined adherence by a woman's self-report that she is screened regularly (e.g., Horton, Romans, and Cruess 1992). In this study, we use a more precise measure of adherence that considers recency of the last exam, a woman's age, and screening history over time, that is, whether a woman had had the age-appropriate number of mammography exams in addition to having had mammography within the past two years.

Third, most studies have not examined whether or not factors associated with adherence are different from those associated with initial or recent utilization (Jepson and Rimer 1993). Typically, mammography studies use a one-part model to examine the predictors of screening. This approach, however, does not allow the analysis of factors that are predictive of different stages of utilization. For example, a one-part model that examines the predictors of adherence versus nonadherence (among all women) could indicate that HMO membership is a predictor of adherence; however, a multipart model that uses one model to examine the predictors of ever having had mammography versus not (among all women), and another model to examine the predictors of adherence versus nonadherence (among women who have ever had mammography) could show that HMO members are only more likely to have an initial exam, while they are equally as likely as non-HMO members to be nonadherent to guidelines over time. In this study, we use multipart, sequential models to analyze separately the predictors of having ever had mammography, having had mammography in the past two years, and adherence to guidelines.

Fourth, we examine the role of shared decision making between patients and practitioners—an important healthcare issue. A woman's self-report that a practitioner recommended screening is a key determinant of mammography utilization (Vernon 1990; White, Urban, and Taylor 1993; Breen, Brown, and Kessler 1996). Most prior studies have assumed that a practitioner recommendation is one-directional; that is, that the practitioner recommends mammography and the woman chooses to comply or not comply with that recommendation. The process by which women and their practitioners make decisions, however, is more interactive (e.g., Fox, Siu, and Stein 1994). In this

study, we examine whether the woman's perception that she participated in the decision to be screened (versus the perception that the doctor decided) is a predictor of utilization.

Fifth, to our knowledge, no studies have examined whether healthcare environment factors, such as mammography facility characteristics, HMO market share, and shortages of primary care providers, are associated with mammography utilization. The changing healthcare environment—with an increasing percentage of the insured population covered by HMOs or managed care plans, as well as differences in practice patterns across areas—may have important implications for mammography utilization. Although numerous studies have examined whether members of HMOs are more likely to receive preventive services and several studies have examined the “spillover” effects of HMOs (Frank and Welch 1985; Luft, Maerki, and Trauner 1986; McLaughlin 1988; Robinson 1991; Clement, Gleason, and Brown 1992; Baker 1995; Chernew 1995; Baker and Corts 1996; Baker 1997), few studies have examined whether HMO market share in an area is associated with utilization of preventive services (Foreman, Paringer, and Mucha 1996). One hindrance to examining the role of environmental factors has been the lack of databases that incorporate both individual and environmental characteristics. For this study we developed a unique database that links individual-level data with county-level data on mammography facility characteristics, HMO market share, and primary care shortages. We predicted that both individual and environmental factors would be associated with screening utilization, in accordance with the “behavioral” model (Andersen and Newman 1973).

METHODS

DATA

We combined data from four sources: individual-level data on women's characteristics and mammography utilization, county-level mammography facility data, county-level HMO market share data, and county-level data on primary care shortage areas. Each woman was assigned county-level data based on her county of residence.¹

The linkage of individual and county-level data enabled us to examine whether women's environments are associated with utilization (Schwartz 1994; Andersen 1995). Variables such as region and urban residence are often used as measures of individuals' environments, but by merging data sets we were able to examine measures that are more specific to mammography

utilization and that are not available in individual-level data sets such as the National Health Interview Survey. For example, we included a measure of HMO membership and, in addition, we included a measure of the HMO environment where a woman lives ("HMO market share"). The unit of analysis is the individual.

UTILIZATION DATA

Data on women's characteristics and their use of mammography are from the 1992 National Health Interview Survey (NHIS) conducted by the National Center for Health Statistics, Centers for Disease Control and Prevention. The NHIS is a cross-sectional, household interview survey representative of the civilian, non-institutionalized population ages 18 or older in the United States. The NHIS is large ($N = 20,974$) with a high response rate (96 percent), and has been used for numerous studies of healthcare utilization, for instance, Paringer, Phillips, and Hu (1991), Phillips (1994), and Phillips et al. (1995). Interviews are conducted in English or Spanish. The NHIS questionnaire consists of two major sections: the basic health and sociodemographic section, which remains constant from year to year, and special supplements that change each year. The 1992 NHIS included two special supplements on cancer: *Cancer Epidemiology* and *Cancer Control*. An adult was randomly selected in each NHIS household to complete one of the two supplements. Data for this study are from the NHIS *Cancer Control Supplement* ($n = 12,035$). Data collected included sociodemographics, insurance status, preventive practices, cancer knowledge and beliefs, and mammography utilization. Further details on the NHIS are in Benson and Marano (1994), and Makuc, Freid, and Parsons (1994).

We included women between the ages of 50 and 74 for prevalence estimates and in sample descriptions (weighted $n = 2,026$). For regression analyses, women without county matches ($n = 705$),² with missing data on other independent variables ($n = 125$), who had never heard of mammography ($n = 146$), and without any access to care ($n = 77$) were excluded.³ The latter two groups of women were excluded because they are not relevant in a study of adherence.

MAMMOGRAPHY FACILITY DATA

Data on the characteristics of mammography facilities are from the 1992 National Survey of Mammography Facilities (NSMF), conducted for the National Cancer Institute (NCI). The NSMF is the largest and only nationally representative survey of mammography facilities. This telephone and mail

survey collected data from a national random sample of the approximately 10,000 mammography facilities in the United States ($n = 1,057$, response rate = 91%). Respondents were self-identified as "the person most knowledgeable about facility services." Data collected included charges, record keeping, and patient follow-up; participation in low-income programs; location; accreditation; procedures; equipment; and personnel (further details on the NSMF are in Hurwitz (1993), Breen and Brown (1994), Brown and Fintor (1994), Brown and Houn (1994), and Houn and Brown (1994).

HMO MARKET SHARE DATA

We obtained data on 1990 HMO market share using the following procedures (details are in the Appendix). First, for each HMO in the United States, we obtained the total enrollment and service area (Group Health Association of America 1991). Second, we distributed each HMO's enrollment among the counties in its service area (based proportionally on county population as well as on incorporating the concentration of enrollees around HMO headquarters). Finally, we computed the total number of enrollees in each county by summing county enrollments over all of the HMOs serving the county. Using the total number of HMO enrollees in each county, we computed HMO market share as the ratio of enrollees to total population. The county-level estimates obtained are consistent with Metropolitan Statistical Area-level estimates from independent sources.

PRIMARY CARE SHORTAGE AREA DATA

We included data from the 1991 Area Resource File (ARF) (U.S. Department of Health and Human Services 1991) on whether a county was a designated primary care shortage area in whole, in part, or not designated. The ARF is a county-based data file, developed by the Health Resources and Services Administration, summarizing secondary data from a variety of sources.

ANALYTICAL APPROACH

We used sequential, multipart models, where each equation is a subset of the prior equation (Maddala 1983). Although multipart models, to our knowledge, have not been used for mammography studies, similar approaches have been used to analyze healthcare utilization; for example, multipart models have been used to analyze utilization in the RAND Health Insurance Experiment (Duan et al. 1983) and to analyze utilization of physician services (Cohen 1993). The use of multipart models allows for a better understanding of the

factors associated with initial mammography utilization, recent utilization, and adherence to guidelines, and it improves the robustness of estimates (Duan et al. 1983).

We conceptualized that women must go through a three-step process in order to be adherent:

1. Since only about 8 percent of women self-refer to mammography facilities (Houn and Brown 1994), women usually need access to a provider to obtain a referral for their initial mammography exam.
2. Women must have had a recent exam, within the recommended interval of one to two years ago.
3. In addition to having had recent mammography, women must have had the age-appropriate number of exams according to screening guidelines over their lifetimes in order to be adherent.

We operationalized this conceptual model by using a set of logistic regression analyses that models women's choices at each step as a function of a set of independent variables; we refer to this as "sequential" analysis. The remainder of this section describes the models and variables in detail.

DEPENDENT VARIABLES

We analyzed three sequential dependent variables:

- Among women with any access to a provider, the first equation models the predictors: 1 = ever had mammography; 0 = never had mammography.

We defined women as having any access to a provider if they reported having a usual source of care (including women who reported more than one usual source), or if they reported having had a doctor visit within two years. Seventy-seven women did not have access using this definition and were excluded. (Although having access to a provider is conceptually the first stage, we did not model these results since the number of women without access is very small in this sample. Note that we excluded only women without any access to care. We included independent variables to examine characteristics of the extent of access (see further on).

- Among women who ever had mammography, the second equation models the predictors: 1 = had mammography within the past two years; 0 = had mammography over two years ago.

We defined recency of mammography based on women's self-report of the date of their last exam. Women who did not know specifically when their

last exam was obtained but who did know that it was "less than a year ago" ($n = 19$) or "one to three years ago" ($n = 21$) were coded as having obtained a mammography in the past two years.

- Among women who had mammography in the past two years, the third equation models the predictors: 1 = had the age-appropriate number of mammography exams over their lifetime; 0 = did not have the age-appropriate number of exams.

The NHIS asked women their age and the number of exams they had had in their lifetimes. We categorized women as "adherent" if they reported a number of exams appropriate for their age, based on screening at least every two years in accordance with guidelines that were first published in 1977 (National Cancer Institute 1977; American College of Physicians 1984; Godillo 1989). In our baseline estimate, we examined biennial rather than annual screening because of differences in guidelines and to provide a conservative estimate of adherence. We also coded women with seven or more exams as adherent, regardless of age, because mammography screening guidelines had only been widely publicized 15 years before the NHIS interviews occurred (National Cancer Institute 1977).

In order to provide a range of estimates for adherence, we varied each criterion in our baseline definition of adherence (see Table 1 further on): (1) including women age 50–65 only, since these women may be more adherent; (2) using the number of exams required for annual rather than biennial screening to determine adherence; (3) assuming that women with four or more exams are adherent regardless of age, based on clinical trials showing that having four exams results in a reduction in breast cancer mortality (Andersson, Aspegren, and Janzon 1988; Tabar et al. 1989; Frisell, Eklund, Hellstrom, et al. 1991); and (4) excluding women who reported having breast problems ($n = 167$), since these women may have had diagnostic exams in addition to screening exams, although, as discussed below, women were asked only about breast problems associated with their last exam. Therefore, this approach likely excludes some women who obtained the appropriate number of screening exams.

INDEPENDENT VARIABLES

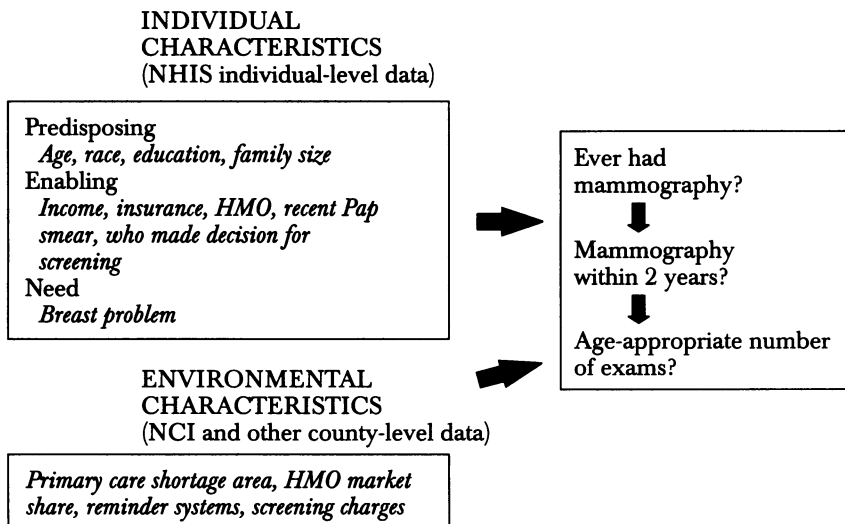
We used the "behavioral" model, which is commonly used for utilization studies, to group variables into "predisposing," "enabling," "need," and "environmental" categories (Andersen and Newman 1973; Aday and Andersen 1974; Andersen 1995). Based on this conceptual model, previous research,

and data availability, we examined the association of the following variables with mammography utilization. Variables and the basic model are shown in Figure 1.

Predisposing Characteristics. A number of sociodemographic characteristics have been found to predispose women to obtain mammography (Vernon 1990; White, Urban, and Taylor 1993; Breen, Brown, and Kessler 1996). We examined age, race, education, and household size.

Enabling Characteristics. We examined several measures of the extent of access to care. Economic resources and insurance coverage, as well as practitioner recommendations, have been found to enable women to obtain mammography (Vernon 1990; White, Urban, and Taylor 1993; Breen, Brown, and Kessler 1996). We therefore examined household income and insurance coverage. We also examined HMO membership, since some studies have found that HMO members obtain more preventive services (Manning, Leibowitz, and Goldberg 1984; Bernstein, Thompson, and Harlan 1991; Luft and Miller 1994; Makuc, Freid, and Parsons 1994). Because women who obtain other preventive services may be more likely to undergo mammography (Vernon 1990), we examined whether women had had a Pap smear in the past three years. We also examined whether women who had had a recent mammography exam perceived that they had participated in the decision ("I

Figure 1: Model and Variables



decided on my own" or "both my doctor and I agreed on it"), or that the doctor had made the decision ("my doctor ordered it"). Response categories were mutually exclusive.

Need Characteristics. Mammography may be either screening or diagnostic. The NHIS data, as well as other data used for mammography studies (Potvin, Camirand, and Beland 1995), do not clearly distinguish screening from diagnostic exams. Women were asked if their last exam had been because of a breast problem, possibly indicating that a diagnostic exam had been performed; however, they were not asked how many of their lifetime exams had been because of problems. Since the focus of our analysis is adherence over time, we did not exclude these women but instead included self-reported breast problems as an independent variable.⁴

Environmental Characteristics. Women living in urban areas or in particular geographic regions may be more likely to be adherent than women living in other areas because of a wider availability of healthcare and mammography services (Hayward et al. 1988), as well as differences in practice patterns. Urban and regional residence, however, are imprecise proxies for environmental characteristics such as mammography availability. We used more precise measures of a woman's environment: whether a county had a shortage of primary care providers (a measure of supply), the average charge for screening mammography since market area prices have been found to be associated with mammography use (Urban, Anderson, and Peacock 1994); and whether mammography facilities had reminder systems for periodic screening mammography, which is a measure of local practice patterns. We also examined HMO market share, since higher concentrations of HMOs may be associated with increased availability of preventive services (Luft and Miller 1994). We used 1990 rather than 1992 market share, since we expected a lag to occur between increases in HMO market share and the increased availability of preventive services. The definition used for HMOs in the NHIS and by the Group Health Association (which we used for determining HMO market share) includes group, staff, and network HMOs, and independent practice associations (IPAs), but not preferred provider organizations (PPOs) (Group Health Association of America 1991; Makuc, Freid, and Parsons 1994).

STATISTICS

We tested bivariate relationships using chi-square tests. We then used logistic regression for multivariate analyses and the Hosmer-Lemeshow goodness-of-fit test to check the fit of our models (Hosmer and Lemeshow 1989).⁵

Data were weighted in accordance with standard procedures in order to adjust for the complex survey design and probabilities of selection and to produce population estimates. We used the SUDAAN program to adjust standard errors.⁶

RESULTS

Only 27 percent of women ages 50–74 years had the age-appropriate number of exams using our baseline definition of adherence (Table 1). In comparison, 59 percent of women had mammography in the past two years (1,198/2,026) and 70 percent had ever had mammography (1,425/2,026). Adherence ranged from 16 percent to 37 percent using different criteria to define adherence.

Significant differences ($p < .05$) across the four mutually exclusive groups (“never had,” “ever had,” “recent,” and “adherent”) were found in terms of age, race, education, household size, recency of Pap smears, perception of the decision-making process, breast problems, primary care shortages, and HMO market share (Table 2).

In regression analyses (Table 3), women were significantly more likely to adhere to screening guidelines (versus having had mammography within two years but not adherent, $p < .05$) if they were age 65 or less; had at least a high school education; had fewer than three household members, higher income, and a recent Pap smear; reported participating in the decision to be screened ($p = .06$); reported breast problems; and lived in an area with no shortage of primary care providers, a higher percentage of mammography facilities with reminder systems, higher HMO market share, and higher screening charges.

Table 1: Percentage of Women Adherent to Screening Guidelines

Age	Criteria for Defining Adherence				Percent of Women Adherent
	Frequency of Screening	Limit on Number of Exams	Women w/Breast Problems Included	n	
50–74	Biennial	7+	Yes	555/2026	27% (baseline definition)*
50–65	Biennial	7+	Yes	475/1339	35%
50–74	Annual	7+	Yes	325/2026	16%
50–74	Biennial	4+	Yes	747/2026	37%
50–74	Biennial	7+	No	452/1859	24%

* Adherent defined as age-appropriate number of exams (based on biennial screening; 7+ exams as adherent regardless of age) and exam in past two years.

Table 2: Sample Characteristics

<i>Characteristics</i>	<i>"Never Had" (Never Had Mammography)†‡ (n = 631)</i>	<i>"Ever Had" (Ever Had Mammography, But Not Past 2 Years) (n = 185)</i>	<i>"Recent" (Had Mammography Past 2 Years, But Not Adherent) (n = 643)</i>	<i>"Adherent" (Had Age- Appropriate No. of Exams) (n = 552)</i>
Age 65 or younger	62%	64%	53%	86%**
White	83%	89%	86%	90%*
High school education or greater	57%	68%	68%	89%**
Three or more persons in household	30%	21%	22%	25%*
< \$20,000 household income	40%	35%	35%	41%
Any insurance	80%	81%	80%	79%
HMO member	17%	18%	19%	15%
Pap smear within 3 years	37%	42%	80%	91%**
Perceived that decision was joint or woman made decision	NA	26%	34%	43%**
Mammogram because of breast problems	NA	3%	10%	18%**
Residing in a county with no primary care shortage	33%	38%	34%	45%**
Lived in area where all facilities surveyed had reminder systems	30%	30%	25%	27%
Lived in area where HMOs had > 10% market share	58%	52%	60%	63%*
Mean total mammography charge	\$116	\$119	\$110	\$115

Note: All *n*'s and percentages are weighted. Chi-square test across groups (except charges).

* $p < .05$; ** $p < .001$.

† Includes women who never heard of mammography.

‡ This table divides the total sample of women ages 50–74 into four mutually exclusive categories. It shows the column percentage; for example, of women who were adherent, 86 percent were under age 65.

In comparison, only household size, income, and recency of Pap smear were significantly associated either with recent mammography or with ever having had a mammography.

DISCUSSION

Our finding that only about one-quarter of women report adhering to screening guidelines has important implications for practitioners and mammography programs and policies. Although the vast majority of women have had initial screening and a majority of women have had recent screening, the large drop in the percentage of women who adhere to guidelines indicates that adherence needs to become a focus of clinical, programmatic, and policy efforts.

Our study is the first to use a national probability sample to measure adherence using the age-appropriate lifetime number of exams. Although we cannot directly compare our results to prior studies because of differences in sample design and definitions of adherence (Lee and Vogel 1995), our results confirm that one-time and recent mammography utilization is high but adherence to guidelines is low (e.g., Horton, Romans, and Cruess 1992; Zapka and Hosmer 1992; Breen, Brown, and Kessler 1996). The low percentage of women who adhere to screening guidelines over their lifetimes and the differences in the correlates between adherence and recency of mammography suggest that having obtained mammography in the past two years is not synonymous with adherence and, therefore, that defining adherence as having an exam within the past one or two years can lead to misleading conclusions. It is difficult, however, to have a perfect measure of adherence without longitudinal follow-up of women and medical chart validation of exams. We therefore used different definitions of adherence to estimate the likely range. Even when we used a generous definition of adherence (four or more exams), only 37 percent of women were adherent.

Two findings are particularly interesting. First, our finding that a woman's report that she participated in the decision to be screened was associated with adherence is a new and important finding. Other studies have found that having a practitioner recommend mammography is a consistently important predictor of mammography utilization (Vernon 1990; White, Urban, Anderson, and Peacock 1993; Breen, Brown, and Kessler 1996). Our results, however, add an important dimension: they suggest that the interaction between a woman and her provider plays a key role in adherence.

Table 3: Factors Associated with Mammography (Logistic Regressions)

Characteristics	Predictors of Ever Having Mammography (= 1) vs. Never (= 0)		Predictors of Having Mammography in Past Two Years (= 1) vs. Had Mammography But Not Past Two Years (= 0)		Predictors of Having Appropriate Lifetime No. of Exams (=1) vs. Mammography in Past Two Years but Not Appropriate Lifetime Number (= 0)	
	Odds Ratios (95% C.I.)		Odds Ratios (95% C.I.)		Odds Ratios (95% C.I.)	
	(n = 990)		(n = 698)		(n = 664)	
≤ 65	1.25 (0.84–1.87)		1.01 (0.46–2.24)		4.27 (2.82–6.48)***	
White	1.13 (0.70–1.83)		1.06 (0.45–2.47)		1.03 (0.53–2.00)	
High school education or greater	1.30 (0.80–2.09)		1.00 (0.32–3.08)		2.16 (1.21–3.85)***	
Three or more persons in household	0.63 (0.40–1.00)**		1.65 (0.49–5.51)		0.56 (0.33–0.94)**	
Income (continuous, in \$1000)	1.04 (1.02–1.08)***		1.04 (0.98–1.11)		1.09 (1.05–1.12)***	
Any insurance	0.76 (0.48–1.19)		0.53 (0.19–1.47)		1.07 (0.67–1.73)	
HMO member	1.56 (0.98–2.47)*		1.31 (0.48–3.59)		0.67 (0.40–1.13)	
Pap smear within 3 years	5.39 (3.75–7.77)***		2.75 (1.13–6.71)**		2.22 (1.27–3.87)***	
Woman and provider or woman decided (vs. provider)	NA		1.10 (0.49–2.47)		1.55 (0.98–2.44)*	
Last mammogram because of breast problems	NA		1.64 (0.45–5.96)		4.14 (2.16–7.93)***	
No primary care shortage (vs. whole or partial shortage area)	1.10 (0.73–1.66)		0.59 (0.27–1.31)		1.58 (1.00–2.49)**	
Facilities with reminder systems in area (continuous, %)	1.06 (0.61–1.85)		1.23 (0.40–3.86)		2.10 (1.14–3.88)***	
HMO market share in area (continuous, %)	1.00 (0.91–1.09)		1.00 (0.87–1.15)		1.14 (1.03–1.27)***	
Average screening charge in area (continuous, in \$)	1.00 (0.99–1.01)		0.99 (0.99–1.00)		1.01 (1.00–1.01)**	

Notes: Data are weighted and adjusted.

Reference groups are in parentheses.

This table shows sequential models which exclude women with missing data, without any access to care, or who had never heard of mammography.

The Hosmer-Lemeshow goodness-of-fit tests were $p = .16$, $.79$, and $.53$, respectively.

* $p < .10$, ** $p < .05$, *** $p < .01$.

Although few studies have examined the interactive nature of decision making and its association with adherence in particular, a study that found that a woman's report of her provider's enthusiasm for mammography was a key predictor of recent screening (Fox, Siu, and Stein 1994) and a study finding that communication between patients and primary care providers facilitated receipt of preventive services (Bindman, Grumbach, Osmond, et al. 1996) also suggest that the interactive nature of the patient-provider relationship is an important factor. The results are also consistent with findings that women's perceptions of the importance of screening are associated with utilization (White, Urban, and Taylor 1993). Despite the marginal statistical significance of this finding ($p = .06$), we emphasize it because it is a factor that can be modified in clinical practice. In addition, it was highly significant ($p = .02$) as a predictor of adherent versus not adherent (i.e., not using a sequential model) and before standard error adjustment.

However, as is often found with other measures of practitioner behavior and patient-provider interactions, the available measure of decision making was based on the woman's self-reported perception rather than on an independent evaluation of the process that occurred. Perceptions of decision making may be a function of other characteristics such as assertiveness, and it is difficult to disentangle the causal relationships with available data. Regardless, the results do suggest that future research should examine patient-provider interactions and the types of institutional and structural factors that influence those interactions.

Second, we found that environmental characteristics are associated with adherence. Women in areas that have more mammography facilities with tracking systems to remind women of periodic screening were more likely to be adherent. These results are consistent with randomized controlled trials that have shown the efficacy of mailed reminders to patients, as well as physicians, in increasing initial and recent screening mammography (McPhee et al. 1989; Skinner, Strecher, and Hosper 1994). We also found that women living in areas without a shortage of primary care providers were more likely to be adherent. This finding suggests that the availability of services may be associated with increased utilization.

The finding that higher HMO market share is associated with higher adherence is intriguing; yet, because no studies, to our knowledge, have examined this issue, we can only speculate about possible explanations. HMOs with higher market share are usually in areas with higher numbers of HMOs, and therefore HMOs in these areas may increase their coverage for preventive services in order to compete with other HMOs for healthier

patients (Wholey and Christianson 1994). Increases in HMO market share may also influence the market by encouraging fee-for-service insurers to emulate HMOs by covering mammography (Baker and Corts 1996). Another explanation is that practitioners who see both HMO and FFS patients may be influenced in their practice patterns if community HMO standards of care encourage the provision of preventive services (Phelps 1992). Note, however, that we did not find that a woman's membership in an HMO was associated with adherence, possibly due to the wide variation in what constitutes an "HMO" or the small number of women in the sample who were members of HMOs.

It is possible, however, that our results for environmental characteristics are due to other unmeasured factors. For example, we suspect that our finding that higher charges are associated with adherence is because of its association with other county characteristics such as urban location. We tested a variable measuring urban/rural location, but it was not significant.⁷

Our approach should not be misinterpreted as committing the classic "ecological fallacy" of using aggregate-level data to make inferences about individuals (Schwartz 1994), since the unit of analysis is the individual. It is important to note, however, that we cannot determine with the available data the causal link between a woman's environment and utilization. We have not measured whether, for example, a particular woman received a reminder from a specific mammography facility, but rather we measured practice characteristics of the environment where the woman lives. Furthermore, our measures of environmental characteristics, as with our measures of individual characteristics, may suffer from measurement error, which increases the variance of our estimates. The results are sufficiently robust, however, to suggest that environmental characteristics should be explored further as possible contributors to utilization.

Although our findings for participation in decision making and for environmental characteristics are the most newsworthy, it should be noted that younger age, higher socioeconomic status, greater need, and the receipt of other screening services may be stronger predictors of utilization, similar to the findings of other studies (Vernon 1990; White, Urban, and Taylor 1993; Breen, Brown, and Kessler 1996). Future research should continue to develop conceptual models and data sets that can be used to examine the predictors of different stages of utilization.

Our study, as with most other studies of utilization, is based on self-report, and women may have incorrectly reported their utilization (Hiatt, Perez-Stable, Quesenbery, et al. 1995). However, studies have found that

women are able to recall accurately whether they had exams within a broad time frame (King, Rimer, Trock, et al. 1990; Zapka, Bigelow, Hurley, et al. 1996), and therefore our measure of adherence may be less prone to self-report bias than are measures that require women to recall exact dates of exams.

Screening behavior is complex and is influenced by a number of correlated factors, some of which we could not measure with our available data, such as out-of-pocket cost or a previous unpleasant screening experience. The factors associated with utilization tend to be complex and correlated, which makes it difficult to separate out their independent effects; some factors may change over time; and there may be selection bias or reciprocal relationships between variables. Therefore, our results should be validated in other data sets, and future research should examine the causal relationships among variables. We used the most recent data available at the time of the study; although rates of adherence may have increased since the data were collected, we expect that the factors associated with adherence remain relatively constant.

Screening behavior is also influenced by characteristics of the practitioner, such as gender and training (e.g., Lurie, Slater, McGovern, et al. [1993]). We could not, however, measure practitioner characteristics with available data. Future studies should examine the interaction of patient and provider characteristics in determining utilization using simultaneous equation models. It would also be useful to examine women's adherence over time, using longitudinal data sets that have measured adherence according to medical records.

Women without county matches, with data missing for other independent variables, who had never heard of mammography, or who had no access to care were excluded from regression analyses. Therefore, although our results for the percentage of women who have been screened is nationally representative, our regression results may not be representative.

This is the first study to our knowledge that has examined the association of mammography facility characteristics and HMO market share with utilization. Although our results are exploratory, the findings suggest that environmental characteristics should be examined in future studies using data sets that simultaneously collect individual and environmental information and that use hierarchical linear models. Several questions could be addressed in future research, for example: What is the impact of specific types of managed care organizations on mammography utilization? Have recently issued quality standards for mammography facilities had an effect on women's utilization and provider referral patterns?

In sum, only a small percentage of women adhere to mammography screening guidelines. These results suggest that adherence needs to become a focus of clinical, programmatic, and policy efforts.

APPENDIX

HMO Market Share Data

This section describes the process by which the county-level estimates of HMO activity were constructed. Further information can be obtained from the third author and is in Baker (1995) and Baker (1997). Conceptually, construction took place in three steps. First, for each HMO in the United States, the total enrollment and the service area, specified by county, were obtained. Second, the enrollment of each HMO was distributed among the counties in its service area. Finally, the total number of enrollees in each county was computed by summing county enrollments over all of the HMOs serving the county. Using the total number of HMO enrollees in each county, HMO market share was computed as the ratio of enrollees to total population.

The primary source of information on HMO enrollments and service areas is the *National Directory of HMOs*, published annually by the Group Health Association of America (GHAA). Each year the GHAA conducts a mail survey, with telephone follow-up, of all known HMOs in the country; among other things, the survey asks their total enrollment and their service area. Survey results are published in the annual *GHAA Directories*. To construct estimates of 1990 county market share, the 1991 *Directory*, which lists enrollment and service area for each of the 567 HMOs in the mainland United States, Alaska, and Hawaii as of December 31, 1990, was used. All but one of the HMOs in the *Directory* indicated their enrollment. In the missing case, data from the 1992 *Directory* was used. Most HMOs (459 of 567) also indicated the counties that they served. However, 108 HMOs (19 percent), did not provide a clear definition of their market area in terms of counties. For these HMOs, market areas were determined by reference to subsequent *Directories*, *The Interstudy Edge*, and/or telephone contact. The correlation between 1990 and 1992 estimates of market share is 0.95.

The next step was to distribute the enrollment of each HMO among the counties in its service area. Initially, this was done by simply distributing enrollment proportionally to county population, an approach used by others for Metropolitan Statistical Area (MSA) estimates (Christianson et al. 1991; Chernew 1995). In addition, since HMO enrollment may be concentrated

near HMO headquarters or since HMOs may locate their headquarters in areas where their enrollment is concentrated, estimates that incorporate both county population and distance from HMO headquarters were constructed. The correlation between estimates produced by the two methods is approximately 0.97. Estimates that incorporate both population and distance are used in analyses shown here.

Once enrollments had been distributed over service areas, the total number of enrollees in each county was computed by summing over the set of HMOs serving that county. Using the set of county enrollment estimates, market share estimates were computed as the proportion of the population enrolled in HMOs.

The validation of these estimates is described in Baker (1995). Since these are the only county-level estimates available, they were compared to MSA-level data from GHAA and Interstudy. Results suggest that the county-level estimates are consistent with the MSA-level estimates. Further, since the county service areas on which the series are based are quite accurate, it is likely that the series themselves are also quite accurate, the nationwide market share patterns found have face validity, and the estimates obtained using different calculation methods are highly internally consistent.

NOTES

1. Linkages were performed by the National Center for Health Statistics (NCHS) to protect confidentiality.
2. We compared women with and without a county match, and there were no significant ($p < .05$) differences in the two variables of most interest: mammography utilization ("ever had mammography," "had mammography past two years," or "adherent to guidelines"), and participation in decision making. The regression results were unchanged when we included women without a county match.
3. The exclusion of these women does not influence the results for the correlates of adherence.
4. In order to examine whether this inclusion influenced the results, we ran the adherence model excluding women with breast problems, and none of the significant correlates changed.
5. Variables were entered simultaneously. Since the focus of this article is on adherence, we built our models so that the variables in all of the models are either significant predictors of adherence and/or are conceptually important and were kept in the models regardless of significance. We tested for interactions, and functional forms of continuous variables were tested using squared terms and categorical variables. Other potential predictors of

utilization (e.g., whether a woman performs breast self-exam, the number of mammography facilities in an area) were tested but deleted from regressions because of multicollinearity or nonsignificance.

6. Note that weighting causes *N*s to fluctuate slightly and that the SUDAAN adjustment generally inflates standard errors, making it more difficult to find significant results.
7. We thank a reviewer for noting that it would have been interesting to examine zip codes as a marker of SES; however, those data were not available.

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